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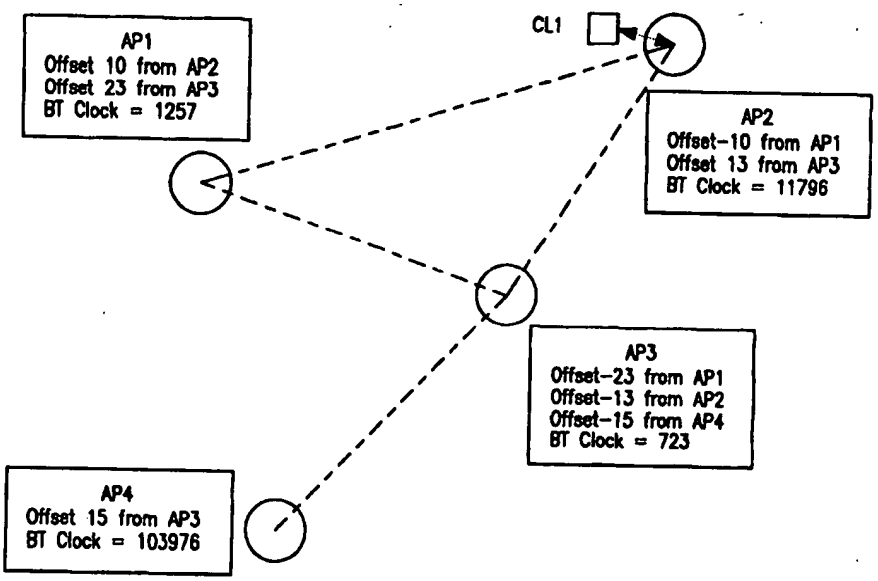
(54) Title: WIRELESS NETWORK AND METHOD FOR PROVIDING IMPROVED HANDOFF PERFORMANCE



(57) Abstract: A wireless network including plural access points (fig.1) for serving first and second areas respectively. A first circuit is operatively coupled to the first and the second network access points to effect communication therebetween. The first circuit is a Bluetooth enabled transceiver. A second circuit is disposed at the first network access point for receiving and storing information with respect to the second network access point. A third circuit is provided with at least one access point for sharing the information with a mobile device adapted to between the first and the second area. The network includes plural network access points and shared information including timing offset and network topology information. The system is adapted to detect a network failure and additions to and deletions therefrom.

WO 02/25967 A1

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WIRELESS NETWORK AND METHOD FOR PROVIDING IMPROVED HANDOFF PERFORMANCE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to wireless networks. More specifically, the present invention relates to methods for facilitating handoff while moving between such networks.

Description of the Related Art

Computer networks allow multiple computers, peripherals and other information storage, retrieval or processing devices to share data. Each device attached to a network is typically referred to as a 'node'. Local Area Networks ("LANs") have historically consisted of nodes interconnected by physical media (e.g., coaxial cable, twisted pair wire, fiber optics, etc.). Recently wireless LANs, the nodes of which are not connected by means of a physical medium, have started to appear in the market. Wireless LANs communicate by means of infrared (IR), radio or other signals. One of the benefits of using wireless LANs is that cabling is not required. This is a particularly useful feature for mobile nodes such as laptop and notebook computers, PDAs (personal digital assistants), and the like. If equipped with an appropriate wireless adapter, the mobile nodes can move around within a predefined coverage area and remain connected to the network.

One method of implementing a wireless LAN is similar to a cellular phone network system. In this method wireless mobile nodes do not communicate directly with each other, but rather send all signals to a central base station, which then redirects the signals to the destination node. In certain systems of this type, each wireless mobile node is allowed to simultaneously participate in different wireless networks.

A wireless technology called 'Bluetooth' is under development to enable ease of synchronization and mobility for a plethora of corporate and consumer applications. Bluetooth is described in BLUETOOTH SPECIFICATION VERSION 1.0B CORE, published in December 1999. Bluetooth technology will open up many possibilities for communication via wireless networks. Currently, Bluetooth enabled wireless networks often include a Network Access Point or 'NAP'. A NAP is typically a stationary, hard-wired transceiver adapted to communicate with mobile wireless devices.

Bluetooth enabled nodes self-organize into "piconets" composed of one master device and a set of slave devices. Since the Bluetooth protocol is based on frequency hopping, the "clock" (slot number) and clock offset of the master, as seen by the slave, are required in order to synchronize the devices with respect to the frequency hops.

There are occasions when a device will need to transfer from one piconet to another due to the limited range of the Bluetooth link. This occurs, for example, when a Bluetooth device is using another device as a network access point, and due to motion the original access point is no longer accessible. This so-called "handoff" between access points requires the device to learn the Bluetooth clock and offset values for the new access point. Further complicating the process is the fact that the location of the device is not accurately known, so the identity of the next access point must be determined by an inquiry process, by which the device basically asks "who's there?" and selects a responder.

Since current Federal Communications Commission (FCC) regulations prohibit hop synchronization between Bluetooth masters, the handoff becomes a probabilistic process that requires a substantial period of elapsed time. Hence, a need exists in the art for a system and/or method for facilitating handoff in wireless, particularly Bluetooth enabled, networks.

SUMMARY OF THE INVENTION

The need in the art is addressed by the wireless network of the present invention. In a most general embodiment, the inventive network includes first and second access points for serving first and second areas respectively. A first circuit is operatively coupled to the first and the second network access points to effect communication therebetween. In the specific illustrative embodiment, the first circuit is a Bluetooth enabled transceiver. A second circuit is disposed at the first network access point for receiving and storing information with respect to the second network access point. A third circuit is provided at at least one access point for sharing the information with a mobile device adapted to move between the first area and the second area.

In the illustrative embodiment, the network includes plural network access points and the information to be shared includes timing offset and network topology information. The system is adapted to detect a failure in the network and additions to and deletions therefrom. Each network access point is adapted to detect an adjacent network access point and establish communication therewith via a background connection. Thereafter, a sequence of frequencies and slots are created based on the network topology and slot timing information. This provides a virtual paging channel in which each slot is spaced in time. Preferably, each slot is

spaced in time such that the device can hop from a first slot to an adjacent second slot with a sufficient time gap to listen for a response.

The inventive network is adapted to broadcast each network access point's identity, relative slot timing, and clock value to each device within each reception area of each other access point in the network.

In accordance with the present teachings, each device is adapted to page a first network access point listed in the virtual paging channel when a change of access point is required. The device then listens for a response from the first network access point. If no response is received, the device pages a second network access point. In the best mode, the virtual paging channel is configured such that the second network access point paged is a next best network access point to page for the device, based at least in part on a location of the device, in response to the network information detected by the network access point and shared with the device.

Hence, the present invention facilitates handoff in wireless, particularly Bluetooth enabled, networks by reducing the time required for a mobile device to acquire a communications channel with a network access point by means of pre-arranged "paging" slots and a broadcasting of the identity and timing of these slots to all devices within range thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a simple network configuration consisting of four access points, with Bluetooth device addresses AP1, AP2, AP3, and AP4, and one client, with address CL1, which is currently receiving service through AP2, and thus an active member of AP2's piconet.

Figure 2 is a diagram which illustrates the four sequences of time slots listed in Figure 1 over a short period of time.

Figure 3 shows the same sequence as Figure 2 over a longer time interval. The shaded slots represent the VPC.

Figure 4 illustrates a VPC as broadcast by AP3 where the slots are sequenced from access points on alternate sides of AP3. This increases the probability of success given that access points will usually have overlapping service areas in the case that other access points are arrayed around an access point AP3.

Figure 5 depicts a movement of a device from CL1 to position CL1' and, in the process, loses contact with an access point AP2.

Figure 6 is a simplified block diagram of an illustrative implementation of a network access point.

Figure 7 is a simplified block diagram of an illustrative implementation of a node in accordance with the teachings of the present invention.

Figure 8 is a flow diagram of the method of adding a new access point in accordance with an illustrative embodiment of the present teachings and with reference to the exemplary network of Figure 9.

Figure 9 is a representation of a wireless network simplified to illustrate the operation of the present invention in connection with the process of adding a new access point.

Figure 10 is a flow diagram of the method of handing off a device or node implemented by the network access point software in accordance with an illustrative embodiment of the present teachings and with reference to the exemplary network of Figure 11.

Figure 11 is a representation of a wireless network simplified to illustrate the operation of the network access point software of the present invention in connection with the process of handing off a node.

DESCRIPTION OF THE INVENTION

Illustrative embodiments and exemplary applications will now be described with reference to the accompanying drawings to disclose the advantageous teachings of the present invention.

While the present invention is described herein with reference to illustrative embodiments for particular applications, it should be understood that the invention is not limited thereto. Those having ordinary skill in the art and access to the teachings provided herein will recognize additional modifications, applications, and embodiments within the scope thereof and additional fields in which the present invention would be of significant utility.

The present invention applies to situations where a Bluetooth enabled device (or node) requires a service which can be accessed via any one of a pool of "access points" distributed about an area. These access points provide relayed access to the service. In the following description, the Bluetooth device is referred to as the "client". It is assumed that the access points can communicate with each other via Bluetooth (in order to determine clock offsets and topology.) (It is possible, but considerably more complicated, to exchange the required information via a wired network.) Also, since access points will usually wish to provide

service to multiple clients simultaneously, the access point will be master of a piconet providing service to clients.

Utilizing this invention, each access point gathers timing offset and topology information about its neighboring access points. This process continues in the background to detect failures and additions to the access point network, as well as to update timing offset information since the access point timings will drift relative to each other.

Once an adjacent access point is identified, each access point establishes a low-rate connection with each adjacent access point. Via these connections the access points mutually agree on a sequence of frequencies and slots which may be considered a "virtual paging channel" or "VPC". Each successive slot in the VPC is spaced in time such that a client can hop from one to the next with enough gap to listen for a response.

The identity, relative slot timing, and Bluetooth clock values are broadcast to all clients participating in each access point's piconet. When a change of access point is required, the client pages each successive access point as listed in the VPC, listens for a response, and moves on to the next if the paged access point does not respond.

Since the page is guaranteed to occur while an access point is listening, the only reason for the absence of a response would be that the access point did not hear the page. Presumably, this is due to the path between the client and the paged access point, so the most fruitful course of action would be to try another access point. The VPC is arranged such that the next entry is the best access point to try in such a scenario.

Figure 1 shows a simple network configuration consisting of four access points, with Bluetooth device addresses AP1, AP2, AP3, and AP4, and one client, with address CL1, which is currently receiving service through AP2, and thus an active member of AP2's piconet. Note that each access point has a totally independent Bluetooth (BT) clock. Although these clocks change independently and are not synchronized, the duration of each slot is very close to the same, so a single time offset satisfactorily describes the relationship between the two slot sequences for a relatively long time. The BT Clock values represent a sample at an instant in time; all are constantly changing.

Figure 2 is a diagram which illustrates the four sequences of time slots listed in Figure 1 over a short period of time. Although the sequences drift relative to each other, the relationship remains valid for these purposes for many seconds at a time.

Figure 3 shows the same sequence as Figure 2 over a longer time interval. The shaded slots represent the VPC. Note that each slot shown occurs on a different frequency, as

determined by the standard Bluetooth hop sequence for each access point. Successive slots of the VPC are selected such that even with a small amount of relative drift (as well as other standard tolerances) the client can listen for a page response and still have time to hop to the next slot if no response is received.

The order of the slots is somewhat arbitrary. In most cases, they will be ordered randomly. Ideally, however, the access points would have enough knowledge of each other's (fixed) location to permit ordering of themselves to minimize the search time. For example, as shown in Figure 4, if other access points are arrayed around AP3, the broadcast VPC should alternate sides so as to increase the probability of success given that access points will usually have overlapping service areas.

Tables 1a - 1d illustrate the VPC information broadcast by each access point in the example. This table contains channel (frequency) information as a convenience to the client; given the device address and BT clock values, the client could compute the channel by itself. Such computation is relatively intensive, however, and is more readily performed ahead of time by the access point (which may have hardware support for the calculation.) Obviously, the broadcast information should be updated before its validity runs out.

Table 1a (Broadcast by AP1)

Piconet Slot	Offset (microseconds)	Target Access Point	Target Slot	Channel
1257	0	AP1	1257	33
1258	602	AP3	725	17
1259	617	AP4	103979	26
1261	615	AP2	11801	41
1263	0	AP1	1263	60
1264	602	AP3	731	3
1265	617	AP4	103985	3
1267	615	AP2	11807	19
Et cetera				

Table 1b (Broadcast by AP2)

Piconet Slot	Offset (microseconds)	Target Access Point	Target Slot	Channel
11796	10	AP1	1257	33
11797	612	AP3	725	17
11799	2	AP4	103979	26
11801	0	AP2	11801	41
11802	10	AP1	1263	60
11803	612	AP3	731	3
11805	2	AP4	103985	3
11807	0	AP2	11807	19
Et cetera				

Table 1c (Broadcast by AP3)

Piconet Slot	Offset (microseconds)	Target Access Point	Target Slot	Channel
723	23	AP1	1257	33
725	0	AP3	725	17
726	15	AP4	103979	26
728	13	AP2	11801	41
729	23	AP1	1263	60
731	0	AP3	731	3
732	15	AP4	103985	3
734	13	AP2	11807	19
Et cetera				

5

Table 1d (Broadcast by AP4)

Piconet Slot	Offset (microseconds)	Target Access Point	Target Slot	Channel
103976	8	AP1	1257	33
103977	610	AP3	725	17
103979	0	AP4	103979	26
103980	623	AP2	11801	41
103982	8	AP1	1263	60
103983	610	AP3	731	3
103985	0	AP4	103985	3
103986	623	AP2	11807	19
Et cetera				

Each time an access point is detected by any existing access point, the VPC must be modified to incorporate the new access point. Although access points will not typically appear and disappear, the existing access points may choose to leave slots in the rotation to facilitate adding new access points. Note that in this example each access point is broadcasting the same table, but with the timing information (slot numbers and offsets) relative to its own Bluetooth clock. In very large networks, it would be desirable to have multiple VPCs organized by access point proximity in order to reduce the latency before the best choice access point is tried.

Client CL1 monitors and stores the VPC information as broadcast by AP2. When it needs to transfer to another access point, it will page AP3 then AP1 (if necessary) as listed in the VPC table. Note that since the VPC provides enough information to determine which frequency the access point is using for each slot in which it is allowed to transmit, CL1 may utilize the VPC information to pre-scan for adjacent access points ahead of a transfer. Such a pre-scan can be further used to optimize handoffs by identifying the exact next access point to be used, or by transferring in advance of loss of signal from the previous access point. These optimizations permit nearly hitless handoffs to be performed.

As shown in Figure 5, assume that CL1 moves to position CL1', and in the process loses contact with AP2. (Note that access points may be able to talk to each other over greater

distances than clients.) At CL1', CL1 will page AP3 and get a response, allowing it to very rapidly join AP3's piconet.

Once established with AP3, CL1 begins monitoring the VPC information broadcast from it. As shown in Table 3, this VPC also contains information for AP4. Thus, if CL1 continues moving in the same direction, it will eventually reach location CL1'', where it may hand off to AP4.

At any time, CL1 may move beyond coverage of communicating access points, for example, on its way to CL1'''. In this case CL1 reverts to the standard means for finding an access point (via the Bluetooth standard inquiry process), as it did originally before connecting with AP2.

Figure 6 is a simplified block diagram of an illustrative implementation of a network access point. As shown in Figure 6, the network access point 100 includes an antenna 110 which provides signals to a transceiver 120, which in the preferred embodiment is a Bluetooth enable radio. The transceiver 120 provides signals to baseband processing hardware 130. The baseband processor 130 digitizes the signals output by the transceiver 120 and separates the digitized signals into packets of data on which error correction and other functions are performed as is common in the art. The baseband processor 130 may be implemented with a microprocessor, application specific integrated circuit (ASIC), field-programmable gate array (FPGA), discrete logic or other suitable arrangement.

A control processor 150 connects with the baseband processor 130 via a bus 140. The control processor 150 is included to control the operation of the network access point 100 using software stored in a read-only memory (ROM) 160. The ROM 160 stores access point control software to be executed by the control processor 150 along with a Bluetooth protocol stack and a Network Interface stack. The control processor 150 writes data to and reads data from random access memory (RAM) 170. In accordance with the present teachings, the RAM 170 contains buffers, working data, and the VPC list. Finally, a network interface adapter 180 is attached to the bus 140 to facilitate connection of the NAP 100 to an internal network. The network interface adapter 180 may be an Ethernet adapter or other suitable adapter depending on the type of internal network to which it is to interface.

Figure 7 is a simplified block diagram of an illustrative implementation of a node in accordance with the teachings of the present invention. As per the NAP 100 illustrated Figure 6, the node 200 includes an antenna 210 which provides signals to a transceiver 220, which is also, in the preferred embodiment, implemented as a Bluetooth enable radio. The transceiver

220 provides signals to baseband processing hardware 230. The baseband processor 230 digitizes the signals output by the transceiver 220 and separates the digitized signals into packets of data on which error correction and other functions are performed as is common in the art. The baseband processor 230 may be implemented with a microprocessor, application specific integrated circuit (ASIC), field-programmable gate array (FPGA), discrete logic or other suitable arrangement.

A control processor 250 connects with the baseband processor 230 via a bus 240. The control processor 250 is included to control the operation of the node 200 using software stored in a read-only memory (ROM) 260. The ROM 260 stores device specific node control software to be executed by the control processor 250 along with a Bluetooth protocol stack. The control processor 250 writes data to and reads data from random access memory (RAM) 270. In accordance with the present teachings, the RAM 270 contains buffers, working data, and the VPC list. Finally, device specific hardware 280 is attached to the bus 240. This hardware might include a fingerprint sensor or microphone and speaker interface by way of example.

Figure 8 is a flow diagram of the method of adding a new access point implemented by the network access point software in accordance with an illustrative embodiment of the present teachings and with reference to the exemplary network of Figure 9.

Figure 9 is a representation of a wireless network simplified to illustrate the operation of the network access point software of the present invention in connection with the process of adding a new access point. The situation depicted in Figure 9 would exist at the point of installation of a new access point. On installation, the new access point might be detected by several access points. Hence, the system must determine which access point will be the first to begin to communicate with the new access point.

As illustrated in Figures 8 and 9, initially an access point A (shown at 342 in Figure 9) is in communication with previously known access points B and C (344 and346). At step 302 a new network access point N (shown at 348 in Figure 9) is detected by an access point A. At step 304, access point A opens a connection to N. At step 306, A checks with N to determine if N supports VPC. If N does not support VPC, then at step 308, A closes the connection and ignores the new access point thereafter.

If, however, at step 306, A determines that N supports VPC, then at step 312, A ascertains whether N is already negotiating with another access point. If so, A allows the other access point to process the new access point N (step 314). If not, at step 316, A begins

to negotiate with N by sending the current VPC list to N. A then awaits a reply from N indicating whether it can fit itself within the existing VPC list. If so, at step 318, N proposes a new VPC list and at step 320 A ascertains whether it can accept the list proposed by N.

If A can not accept the list proposed by N, at steps 322 and 324, A proposes a new VPC list and sends it to N. If at step 318, N accepts the list proposed by A or if at step 320 A accepts the list proposed by N, then at step 326, A closes the connection to N and broadcasts the new VPC list (step 328). Finally, at step 330, NAPs B, C and N receive and rebroadcast the new VPC list upon agreement with same.

Figure 10 is a flow diagram of the method of handing off a device or node implemented by the network access point software in accordance with an illustrative embodiment of the present teachings and with reference to the exemplary network of Figure 11.

Figure 11 is a representation of a wireless network simplified to illustrate the operation of the network access point software of the present invention in connection with the process of handing off a node. The situation 430 depicted in Figure 11 would exist at the point a device or node 401 is in communication with an access point.

As shown in Figures 10 and 11, at step 402, the device 401 is detected by the network and at step 404, the device 401 receives periodic rebroadcasts of the VPC list from an access point (e.g., access point A). Now assume that at step 406, the device 401 loses its connection with the access point A. Accordingly, at step 408, the device 401 begins to select access points from the VPC list. Inasmuch as the device 401 knows the timing and frequency of each access point it pages from the VPC list, it expects a response immediately. If it is not received, the device proceeds to the next access point on the list. This is depicted at steps 410 - 424. At step 410, the device checks to determine whether the next access point on the list is the access point with which it recently lost contact. If so, at step 412, it moves on to the next entry on the list. If not, at step 414, the device 401 pages the access point per its channel and timing offset entry in the VPC list. A sample VPC list is shown in Figure 12.

At step 416, the device 401 listens for a response. If a response is received, at step 418, the device 401 connects with the responding access point. If no response is received at step 416, then at step 412, the device 401 proceeds to the next entry on the list. This next entry is checked to determine if it is associated with the access point with which the device 401 recently lost contact (step 410). If the list is exhausted, at step 424, a standard inquiry (e.g., the Bluetooth standard inquiry) is used to locate an access point. Thus, the present invention

has been described herein with reference to a particular embodiment for a particular application. Those having ordinary skill in the art and access to the present teachings will recognize additional modifications applications and embodiments within the scope thereof.

It is therefore intended by the appended claims to cover any and all such applications, modifications and embodiments within the scope of the present invention.

Accordingly,

WHAT IS CLAIMED IS:

1. A wireless network comprising:

a first network access point for serving a first area;

a second network access point for serving a second area;

first means operatively coupled to said first and said second network access points for effecting communication between said first network access point and said second network access point;

second means disposed at said first network access point for receiving and storing information with respect to said second network access point; and

third means for sharing said information with a mobile device adapted to move between said first area and said second area.

2. The invention of Claim 1 wherein said information includes timing offset information.

3. The invention of Claim 1 wherein said information includes network topology information.

4. The invention of Claim 1 wherein said second means includes means for detecting a failure in said network.

5. The invention of Claim 1 wherein said second means includes means for detecting additions to and deletions from said network.

6. The invention of Claim 1 wherein said network includes plural network access points.

7. The invention of Claim 6 wherein said second means includes means for detecting an adjacent network access point.

8. The invention of Claim 7 wherein said first means includes means for establishing communication with said adjacent access point.

9. The invention of Claim 8 wherein said second means includes means for creating a sequence of frequencies and slots in response to said information.

10. The invention of Claim 9 wherein said second means includes means for creating a virtual paging channel in response to said information.

11. The invention of Claim 9 wherein each channel is spaced in time such that said device can hop from a first slot to an adjacent second slot with a sufficient time gap to listen for a response.

12. The invention of Claim 11 wherein said second means includes means for broadcasting each network access point's identity to each device within each reception area of each other network access point in said network.

13. The invention of Claim 12 wherein said second means includes means for broadcasting each network access point's relative slot timing to each device within each reception area of each other network access point in said network.

14. The invention of Claim 13 wherein said second means includes means for broadcasting each network access point's clock value to each device within each reception area of each other network access point in said network.

15. The invention of Claim 14 further including fourth means disposed on said device for paging a first network access point listed in said virtual paging channel when a change of access point is required.

16. The invention of Claim 15 wherein said fourth means includes means for listening for a response from said first network access point.

17. The invention of Claim 16 wherein said fourth means further includes means for paging a second network access point if a response is not received from said first paged network access point.

18. A mobile device for use in a network having a first network access point for serving a first area and a second network access point for serving a second area, said device comprising:

means for paging said first network access point when a change of access point is required;

means for listening for a response from said first network access point; and

means for paging a second network access point if a response is not received from said first paged network access point.

19. A wireless Bluetooth enabled network comprising:

a plurality of network access points including a first network access point for serving a first area and a second network access point for serving a second area;

a Bluetooth enable wireless transceiver disposed on each network access point for effecting communication between said plural network access points;

memory disposed at each access point for receiving and storing topology, failures and/or slot timing information with respect to said network;

circuitry disposed at each access point for creating a virtual paging channel including a sequence of frequencies and slots in response to said information, each of said slots being spaced in time such that a mobile client device adapted to move between areas covered by said network access points, specifically said first area and said second area, can hop from a first slot to an adjacent second slot with a sufficient time gap to listen for a response;

circuitry disposed at each access point for broadcasting each network access point's identity, relative slot timing, and/or clock value to each device within each reception area of each other network access point in said network; and

paging circuitry disposed on each said device for paging a first network access point listed in said virtual paging channel when a change of access point is required, said paging circuitry including:

a receiver for listening for a response from said first paged network access point and

a pager for paging a second network access point if a response is not received from said first paged network access point.

20. The invention of Claim 19 further including circuitry disposed at each access point for detecting adjacent network access points, and circuitry for establishing communication with each of said adjacent access points.

21. The invention of Claim 19 wherein said virtual paging channel is arranged such that the second network access point paged is the next best network access point to page for said device in response to said information.

22. The invention of Claim 21 wherein said arrangement is based at least in part on a location of said device.

23. A method for providing communication with a device in a wireless network including the steps of:

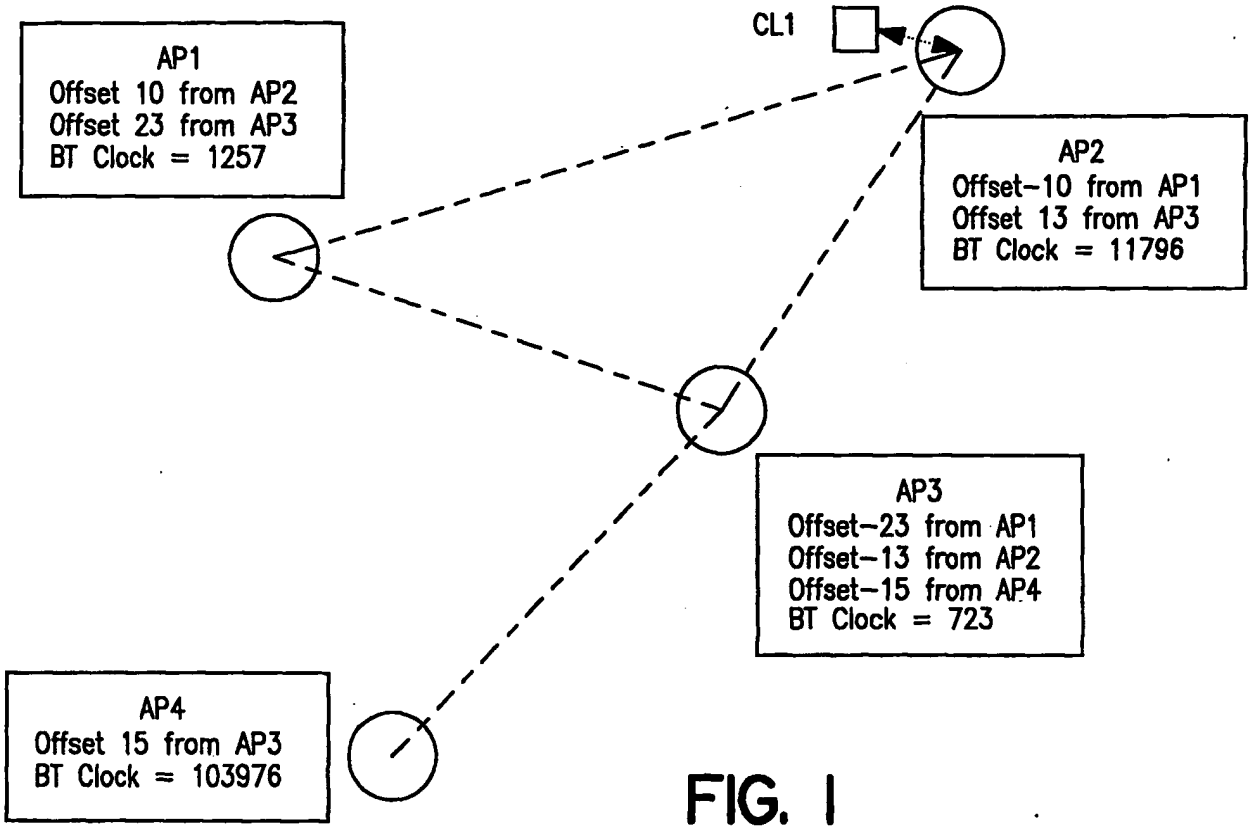
providing a first network access point for serving a first area;

providing a second network access point for serving a second area;

effecting communication between said first network access point and said second network access point;

receiving and storing information at said first network access point with respect to said second network access point; and

sharing said information with said mobile device adapted to move between said first area and said second areas.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AP2
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Offset–13 from AP2
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AP4
Offset 15 from AP3
BT Clock = 103976

FIG. 1

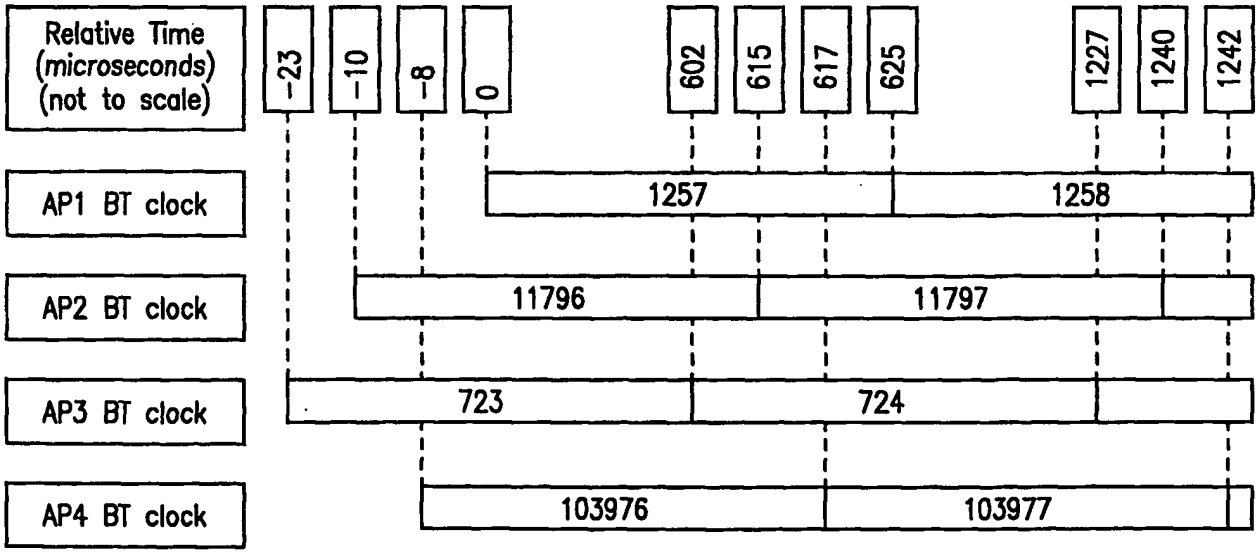

Relative Time (microseconds) (not to scale)
-23
-10
-8
0
602
615
617
625
1227
1240
1242
AP1 BT clock
1257
1258
AP2 BT clock
11796
11797
AP3 BT clock
723
724
AP4 BT clock
103976
103977

FIG. 2

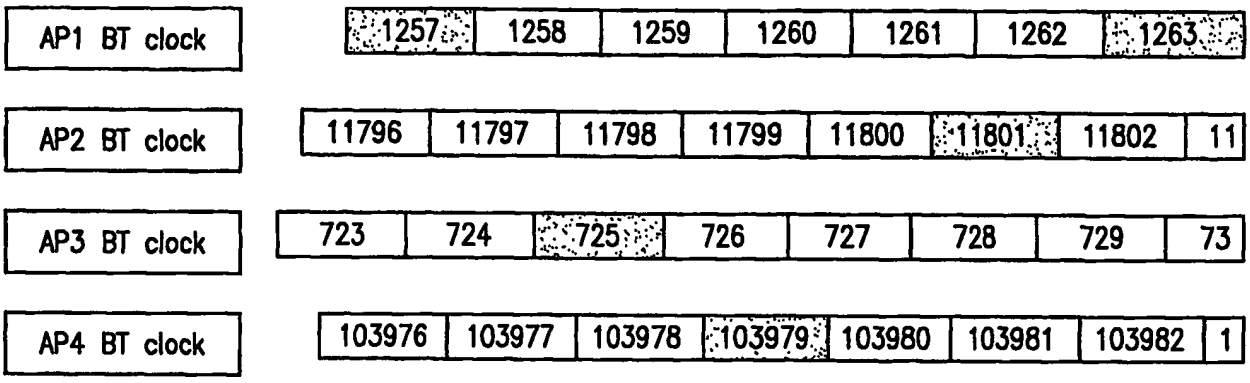

AP1 BT clock
1257
1258
1259
1260
1261
1262
1263
AP2 BT clock
11796
11797
11798
11799
11800
11801
11802
11
AP3 BT clock
723
724
725
726
727
728
729
73
AP4 BT clock
103976
103977
103978
103979
103980
103981
103982
1

FIG. 3

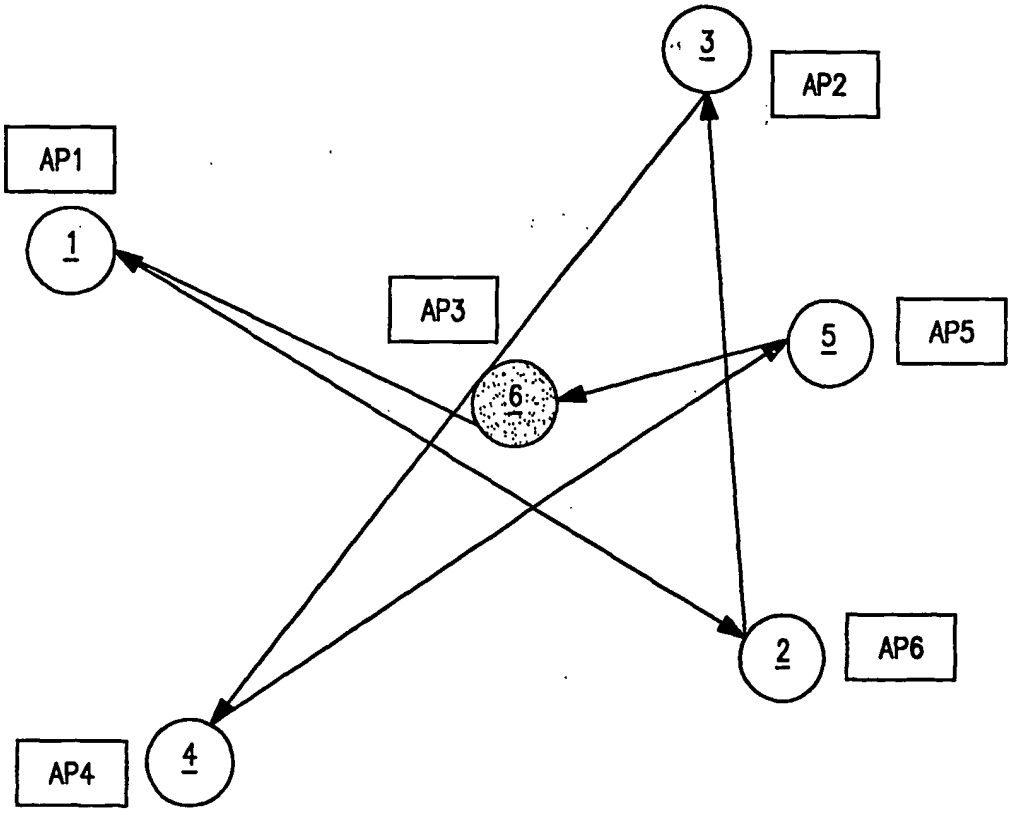

AP1
1
AP2
3
AP3
6
AP5
5
AP6
2
AP4
4

FIG. 4

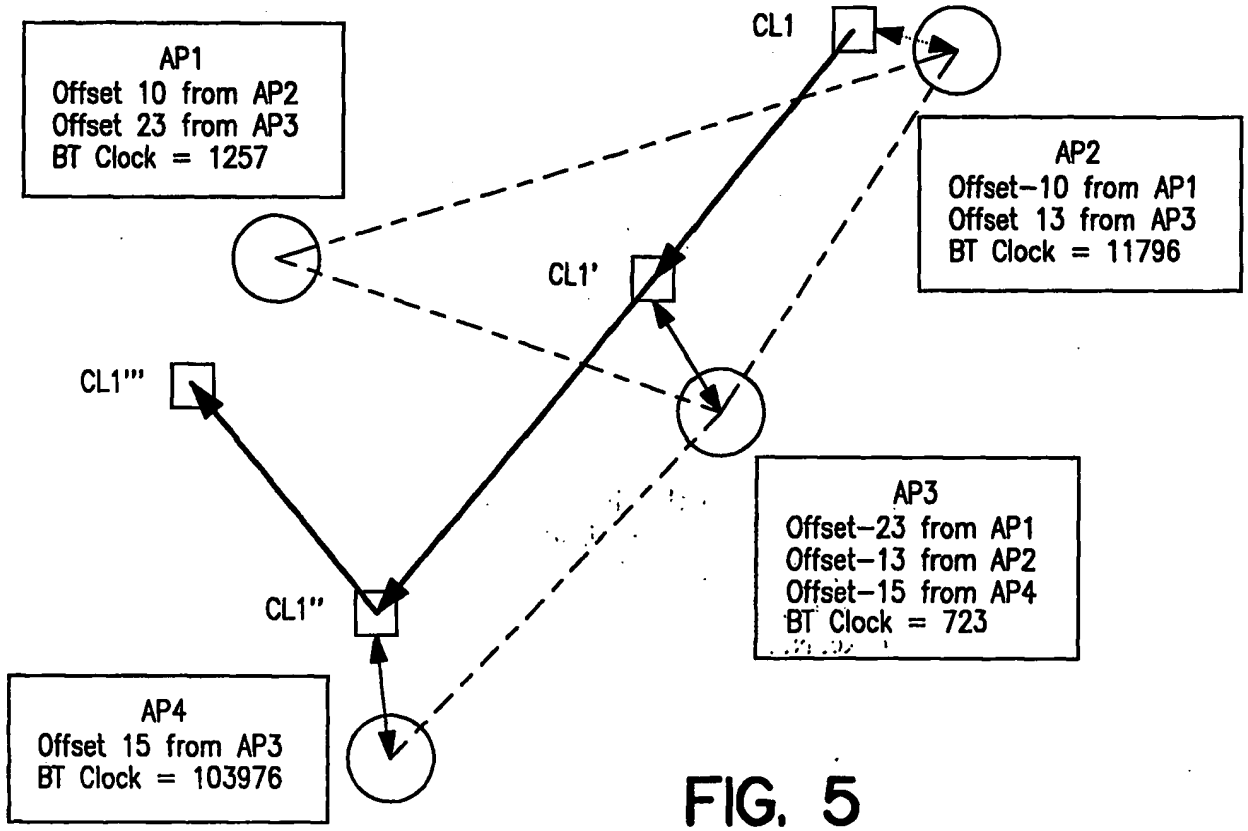

AP1
Offset 10 from AP2
Offset 23 from AP3
BT Clock = 1257
CL1
AP2
Offset-10 from AP1
Offset 13 from AP3
BT Clock = 11796
CL1'
CL1'''
AP3
Offset-23 from AP1
Offset-13 from AP2
Offset-15 from AP4
BT Clock = 723
CL1''
AP4
Offset 15 from AP3
BT Clock = 103976

FIG. 5

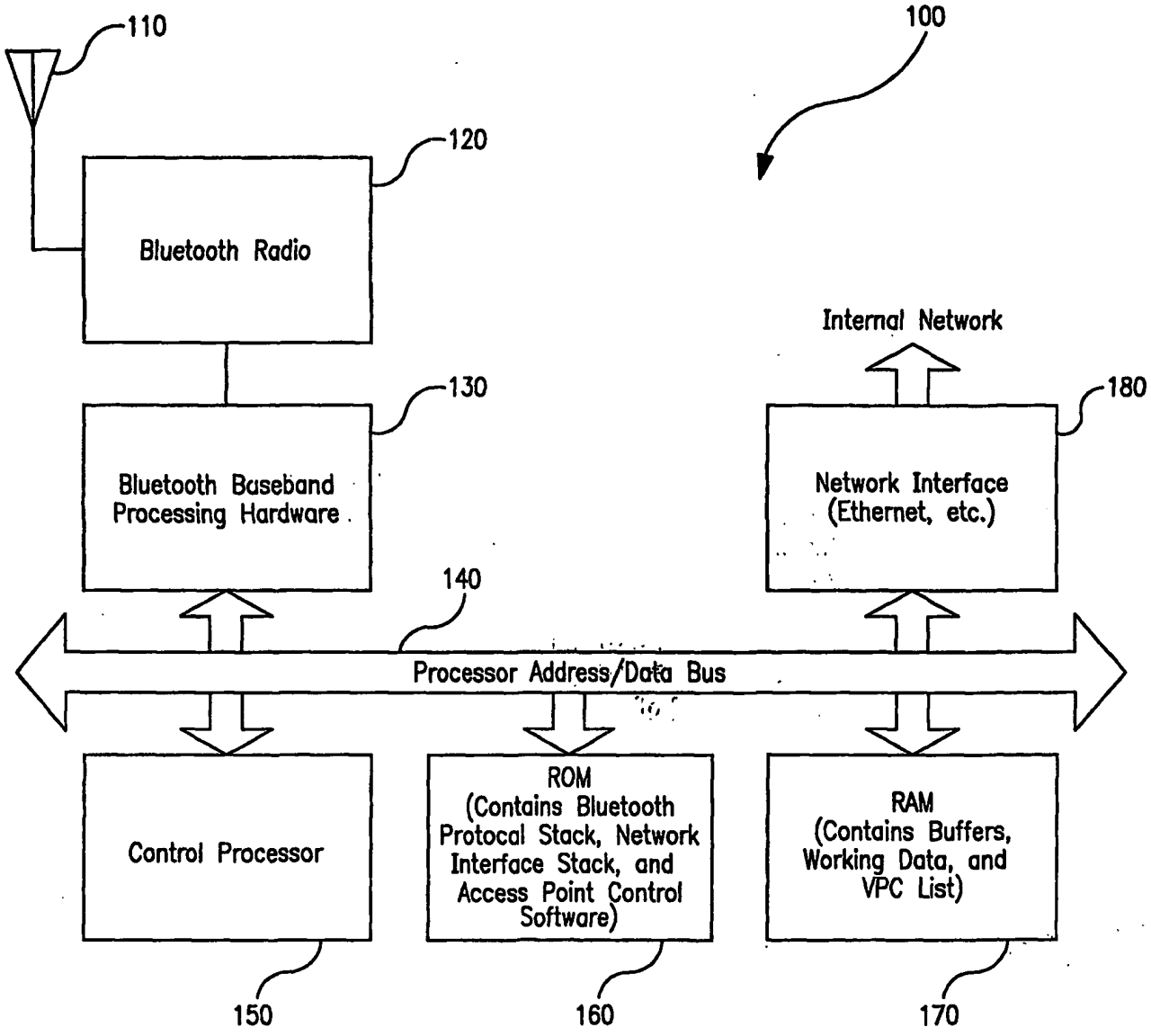

110
100
120
Bluetooth Radio
Internal Network
130
180
Bluetooth Baseband Processing Hardware
Network Interface (Ethernet, etc.)
140
Processor Address/Data Bus
Control Processor
ROM (Contains Bluetooth Protocal Stack, Network Interface Stack, and Access Point Control Software)
RAM (Contains Buffers, Working Data, and VPC List)
150
160
170

FIG. 6

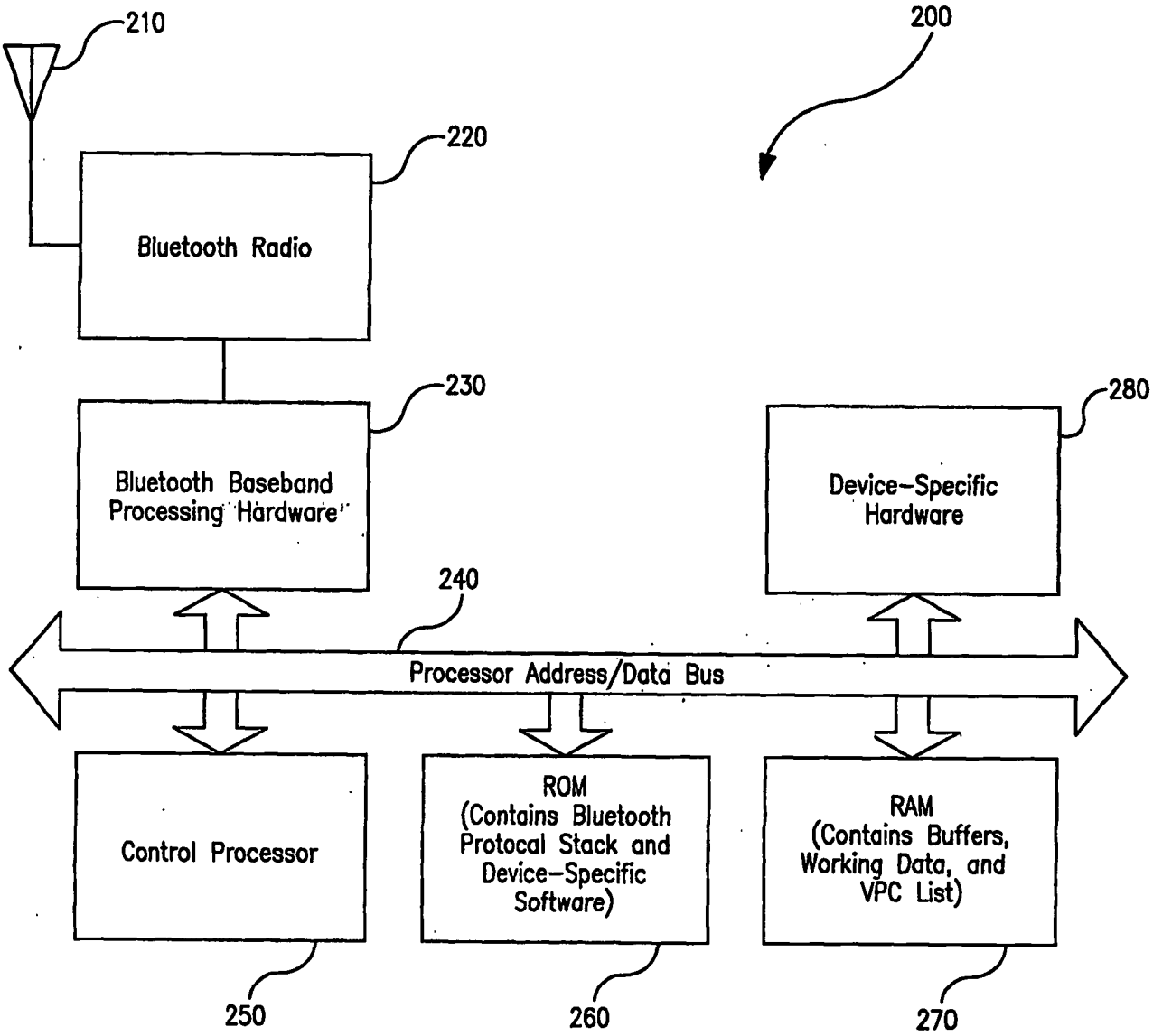
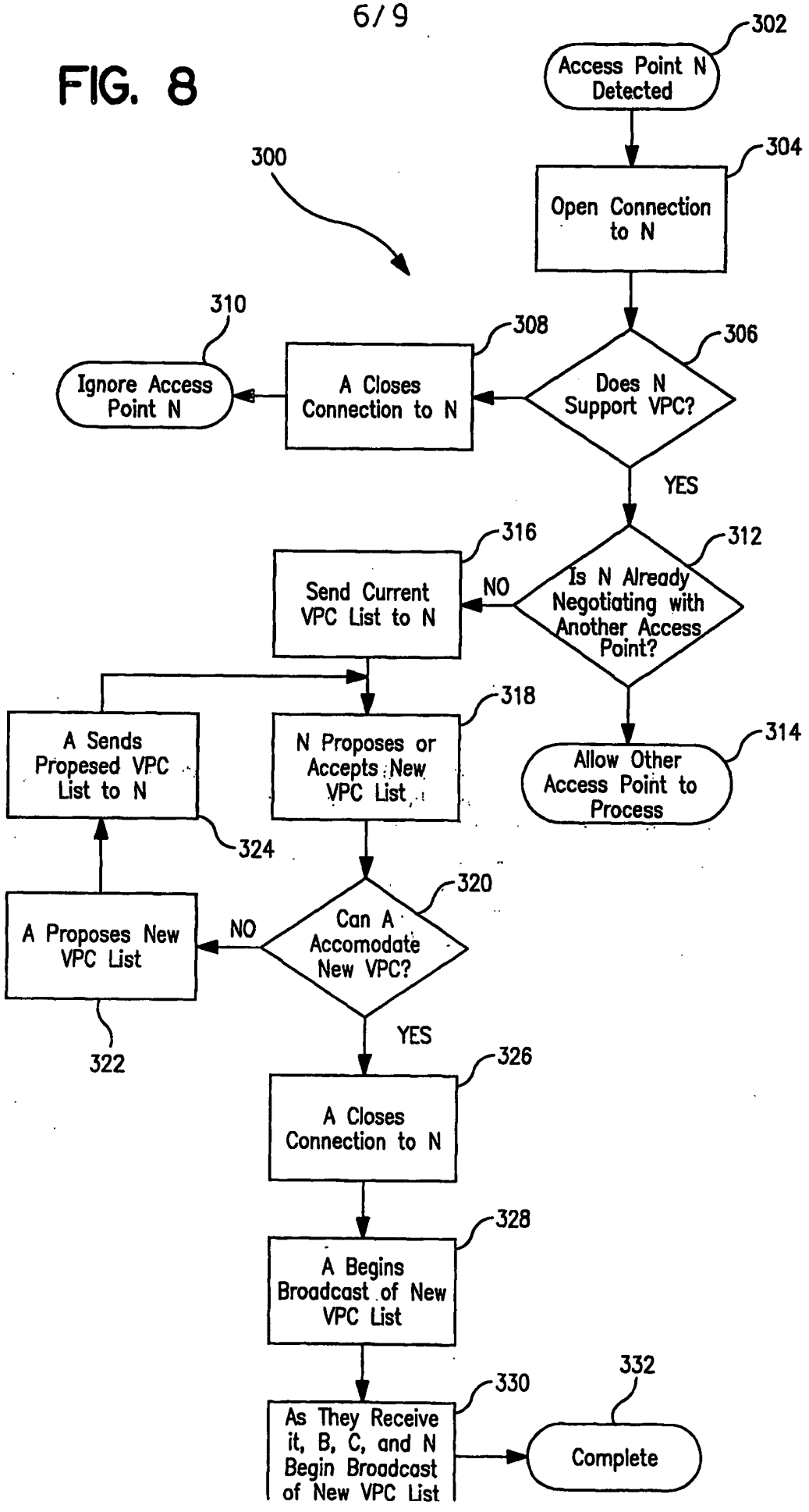

210
200
220
Bluetooth Radio
230
280
Bluetooth Baseband Processing Hardware
Device-Specific Hardware
240
Processor Address/Data Bus
Control Processor
ROM (Contains Bluetooth Protocal Stack and Device-Specific Software)
RAM (Contains Buffers, Working Data, and VPC List)
250
260
270

FIG. 7

FIG. 8


300
302
Access Point N Detected
304
Open Connection to N
306
Does N Support VPC?
308
A Closes Connection to N
310
Ignore Access Point N
YES
312
Is N Already Negotiating with Another Access Point?
NO
316
Send Current VPC List to N
314
Allow Other Access Point to Process
318
N Proposes or Accepts New VPC List
320
Can A Accomodate New VPC?
NO
A Proposes New VPC List
322
A Sends Propesed VPC List to N
324
YES
326
A Closes Connection to N
328
A Begins Broadcast of New VPC List
330
As They Receive it, B, C, and N Begin Broadcast of New VPC List
332
Complete

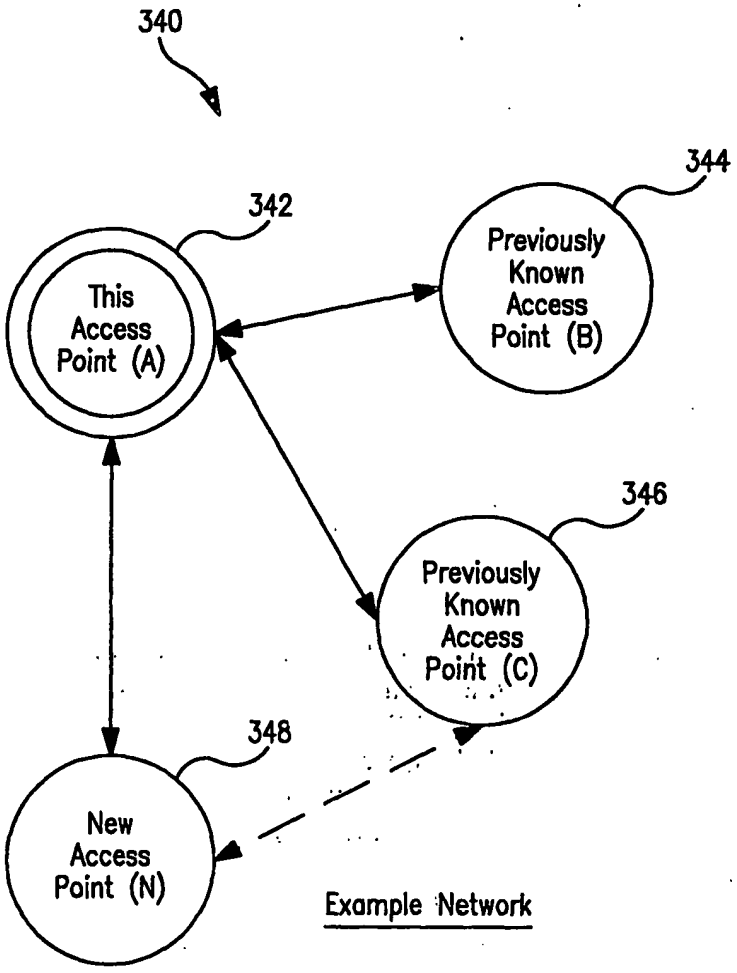
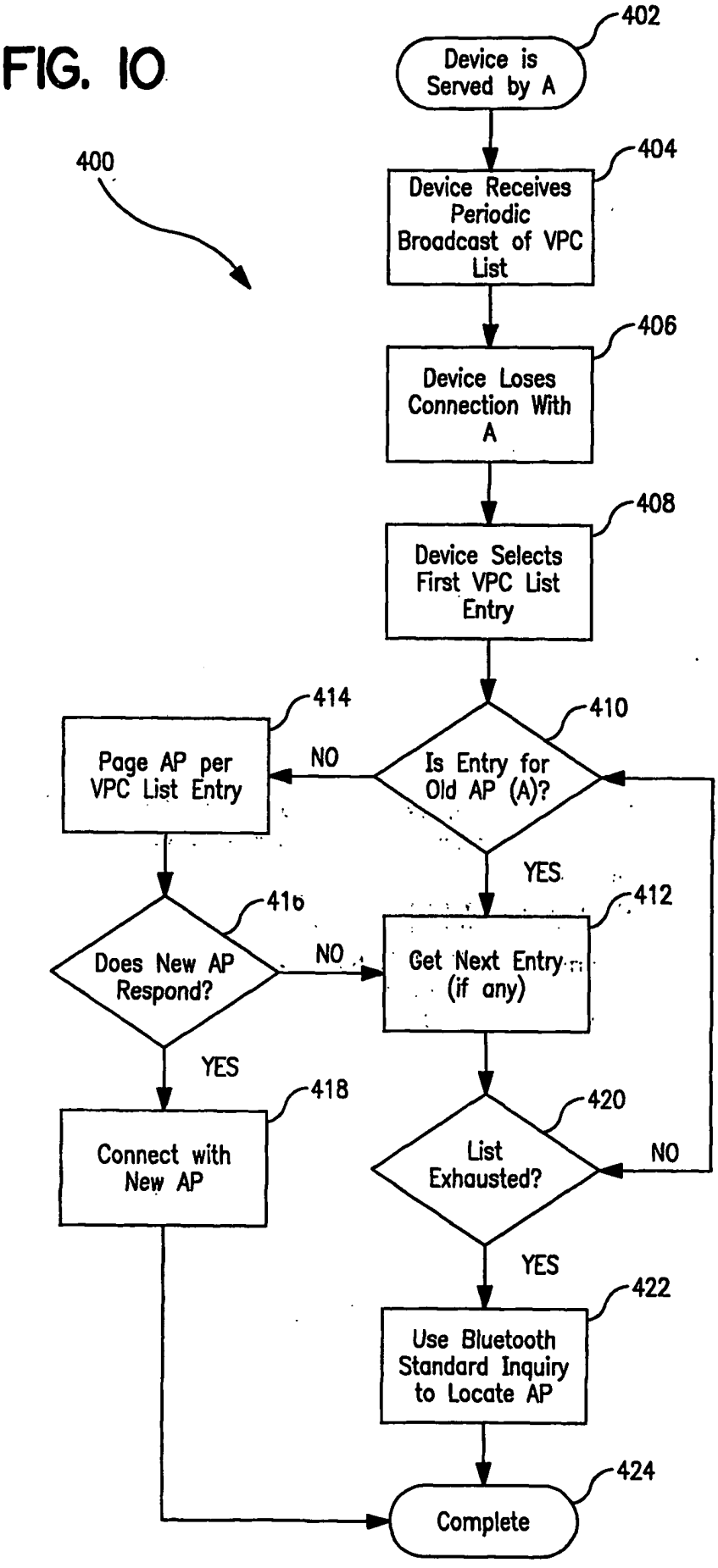

340
342
344
346
348
This Access Point (A)
Previously Known Access Point (B)
Previously Known Access Point (C)
New Access Point (N)
Example Network

FIG. 9

FIG. 10


400
402
Device is Served by A
404
Device Receives Periodic Broadcast of VPC List
406
Device Loses Connection With A
408
Device Selects First VPC List Entry
410
Is Entry for Old AP (A)?
NO
414
Page AP per VPC List Entry
YES
412
Get Next Entry (if any)
NO
416
Does New AP Respond?
YES
418
Connect with New AP
420
List Exhausted?
NO
YES
422
Use Bluetooth Standard Inquiry to Locate AP
424
Complete

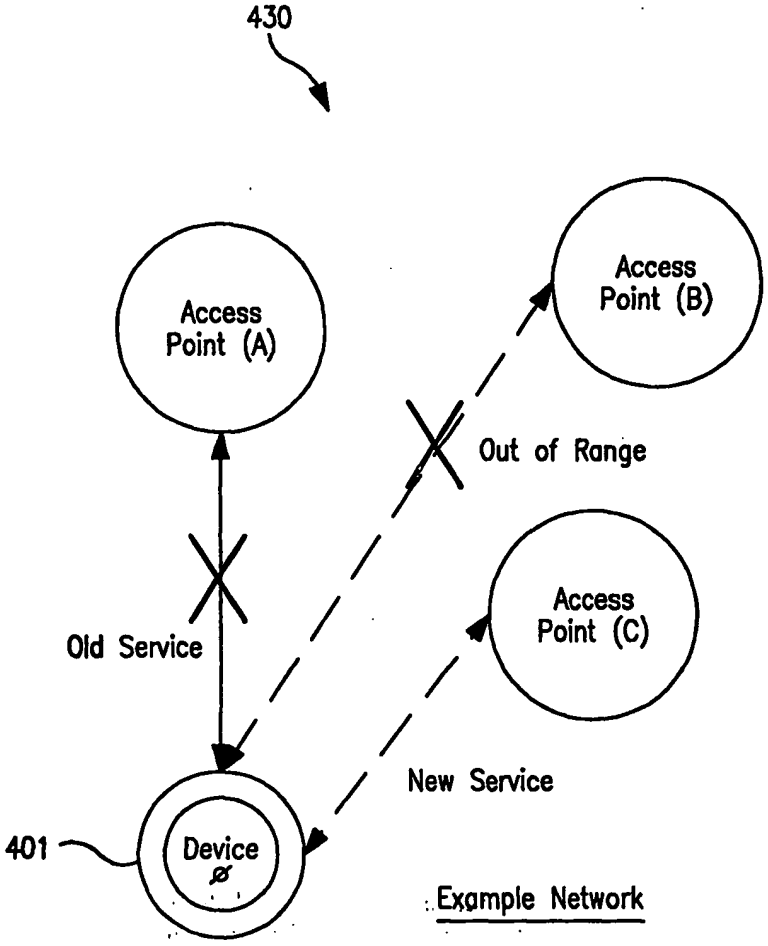


FIG. 11

Example VPC List

AP A Offset 0 Slot 4
AP A Offset 15 Slot 7
AP A Offset 3 Slot 17

FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/28166

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : H04Q 7/20

US CL :455/432, 552, 554, 555, 557, 560, 436, 439

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 455/432, 552, 554, 555, 557, 560, 436, 439

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6,091,951 A (STURNIOLO) 18 JULY 2000, abstract, Fig. 1-3, Fig. 5a, Fig. 6-9, Fig. 11-14, col. 6, line 60-67, col. 27, line 54-65.	1-23
Y	US 6,069,588 A (O'NEILL, JR) 30 MAY 2000, abstract, col. 2, line 61 to col. 3, line 9, col. 6, line 13-16, col. 6, line 48-65	1-23
Y	WO 99/48315 A1 (RAUTIOLA ET AL.) 23 SEPTEMBER 1999, Fig. 12-13, Fig. 1-11, page 21 last paragraph to page 22 first paragraph.	1-23
Y	RD 435,079 A 10 JULY 2000, title, abstract, Fig. 2, left to right column.	1-23

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 01 NOVEMBER 2001	Date of mailing of the international search report 09 JAN 2002
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer DANIEL HUNTER Telephone No. (703)-308-6732

Form PCT/ISA/210 (second sheet) (July 1998)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/28166

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6,061,563 A (LEE) 09 MAY 2000, abstract, Fig. 1, Fig. 3, Fig. 4, col. 1, line 18-31, col. 2, line 13-16, col. 4,line 56 to col. 6, line 11.	1-23
Y	US 5,923,702 A (BRENNER ET AL.) 13 JULY 1999, Fig. 1-3, absctrac, col. 2, line 5-9, col. 5, line 26-42, col. 5, line 50-56.	2, 9, 11, 13, 14
Y	US 5,570,366 A (BAKER ET AL.) 29 OCTOBER 1996, abstract, Fig. 2-7, col. 6, line 35-44.	3, 5
Y	US 6,038,212 A (GALAND ET AL.) 14 MARCH 2000, abstract.	4
Y	US 5,237,321 A (OLIWA) 17 AUGUST 1993, abstract, title, Fig. 2, Fig 3A-4, item 53, item 54, col. 6,line 11-16.	17